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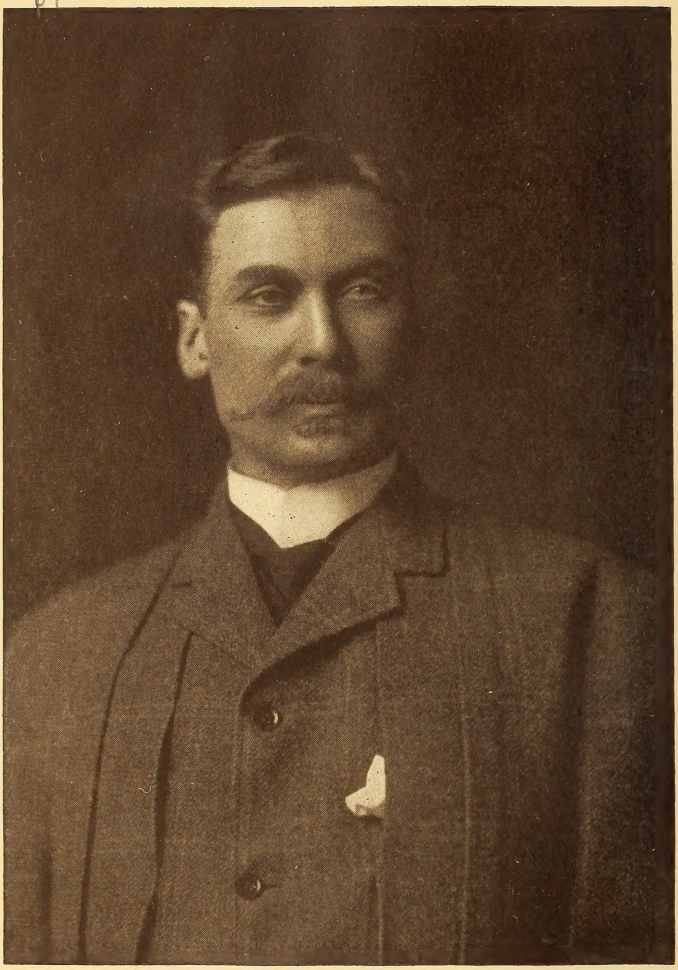

R. W. Leonard.

Applied Science

INCORPORATED WITH

TRANSACTIONS OF THE UNIVERSITY OF TORONTO ENGINEERING SOCIETY

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THE SCOPE OF ENGINEERING IN CANADA.

R. W. LEONARD, C.E.

Mr. Chairman and Gentlemen,—I esteem it an honor to have been requested by the President of your Engineering Society to address you on some engineering subject of my own selection, and in a rash moment I consented, not realizing at the time that your Society embraced men of wide experience in the many fields of engineering since graduating from one of the foremost technical schools in America.

Since realizing the gravity of the situation and balancing it up with my natural aversion for hard work, I have decided to give a very general short address on engineering in which the points dealt with may be very stale and uninteresting to the seniors, but may be of some value to the younger members who are the only ones I can hope to influence, as I am not long out of the ranks of juniors myself, having had very little experience in some essential matters—particularly, as you will observe, in making addresses in public.

In this connection I may express my admiration of the teaching of the art of public speaking which is now given generally in some of our colleges. In my day at college, this was neglected and the result is that I have several times envied the assurance and ability displayed by youngsters of fourteen years in public speaking. This is an important matter for an educated man in any walk of life that he may be able in public to express his thoughts logically, clearly, and concisely, and with the confidence that comes of practice.

An engineer, according to the dictionary, is one who uses or has to do with the construction of engines or machines; or of works in which machinery is extensively employed. He is also sometimes defined as one who utilizes the forces of nature for the benefit of man. Someone whose energies were mostly directed toward railway location, construction and maintenance, has defined an engineer as "a man who can make a dollar do the most work." This last is a definition not to be despised as the financial result is one of the most important measures of the

* Read before the Engineering Society, Oct. 5th, 1910.

success of all engineering problems, and any man who cannot carry out his work satisfactorily in this regard will not be considered by his employer as a successful engineer. On the other hand, where a reasonable expenditure will place the success of a work beyond peradventure, the expense must not be spared.

Advancing civilization has so complicated man's requirements and multiplied the field of endeavor of the man whose profession of old was confined in the army to the handling of artillery, and in civil life to the construction of roads, bridges, buildings, and steam engines, that perhaps a good definition today of an engineer would be "a man who does things."

By the way, the Ancient Romans designated the chief of the highest members of their great colleges of priests, Pontifex Maximus, or the Chief Bridge Builder, from which we get the word Pontiff, all of which shows the early connection between the church and the civil engineer, and is only another proof of its antiquity, respectability, and honor of the profession, and explains the affinity of engineers to the church which is so conspicuous to this day.

All this raises the question if the French name "Ingineur," spelt with an I, and probably related to our word "Ingenuity," would not be a more appropriate designation for our profession. This is a suggestion which I leave to some of you who know something of philology.

Reverting to the financial definition of the term engineer, and assuming its correctness in many branches of the profession, then, an engineer's education is not complete until the engineer has had experience in executing the work as well as in the planning of it, and the measurement of it as done. In my opinion therefore, a young civil engineer who intends to specialize in public works, such as railway, canal, or dock work, should take one contract for the purpose of learning the "practical" part of the work—what the dollar is worth in labor and material, and how to use it to best advantage. He may lose money, but he will gain more valuable experience. My first appreciation of this practical knowledge was acquired through observing a successful contractor timing with his watch the trips the teams were making with the wheel scrapers, and figuring the cost of moving the earth per cubic yard therefrom.

Now, as my remarks apply to the juniors of the profession, I will venture upon some advice based on my limited experience, notwithstanding my familiarity with the saying that "advice is worthless, as the wise man does not need it, and the fool won't take it." One of the first things necessary to success in life is a full appreciation of the value of "law, order, duty and restraint, obedience, discipline," as Kipling puts it, in other words, executive ability. These are not taught or practised in all colleges, and more's the pity for the chances of success in after-life for the students. These can best be acquired through

military training which is well worth your while, for these reasons alone. What a common experience it is to find a well-educated technical man absolutely unqualified to direct the operations of half a dozen men! Cultivate a spirit of absolute loyalty to your superiors, speaking of them and to them respectfully on all occasions with deference to their opinions. Require the same deference from your subordinates while on duty and this is best taught by your own example. Be equally loyal to your subordinates, paying attention to their suggestions and recommendations, and giving them due credit when you find their advice worthy of adoption. This brings out their hearty co-operation and insures their interest in the work. The advantage of such co-operation is apparent if one thinks of how little he alone can do and how much he is dependent upon the detail work of his assistants.

When given an opportunity to reorganize and carry on a work started by another, don't make radical changes too quickly. Better continue in the old methods for a little while, even if apparently faulty, until you have ample time to fully grasp the situation, and then make changes one at a time, using the men and materials on the work so far as possible.

Learn to judge men and their ability from personal observation rather than from written references, and if an assistant is not a success in the work you have set him to, try him in some other department, if he be a desirable character. By so doing you will get a staff about you whose capacities are known and on whom you can rely. This is on the old principle that " 'Tis better to live with the devils you know than to go to the devils you don't know."

Of course, no one man can get a thorough education in college in all the branches of the profession, including mechanics, mining, metallurgy, chemistry, electricity, hydraulics and sanitary engineering—as it would take a life-time.

There is a general ground work common to all, however, that can be acquired at college, and the actual education in any one branch must be obtained by the student after leaving college through experience and close study. This remark is intended to chasten any youngster who has just got his degree and who might therefore consider himself fully qualified to teach his maternal ancestor the noble art of sucking eggs. Please do not infer from this that all the older members of the profession are "grannies," as I am too nearly graduating into their ranks to make such a suggestion.

Though that tendency of some graduates is not to be commended, engineers need to have much self-confidence, and be prepared in this young country to take hold of any work in any branch of the profession that may present itself, and must have the courage to take the responsibility of that work and to carry it through to success.

A few years ago in Canada, civil engineering meant railway or canal surveys and construction, and some water supply and sewage works, and the profession consisted of a very small but select company of men, who set the pattern of loyalty to employers, of industry and integrity to the latter generation that the civil engineers in Canada to-day are proud to acknowledge and to emulate.

I remember being one of only three candidates for matriculation in the faculty of Applied Science at McGill, and I dropped out for want of necessary funds to take the course. Now the students in Applied Science in Canadian colleges are numbered by the hundreds and the Can. Soc. C.E. enrolls about 1,400 corporate members, and one of our ablest engineers estimates that "it requires the expenditure of $150,000,000.00 per annum on engineering works to keep us all employed and give us a moderate remuneration." . . . . . "And we cannot expect the long continuance of the expenditure of capital for engineering works which is required to keep us all going."

If the saying attributed to one of our foremost statesmen that "The 20th century belongs to Canada," and I believe it does in the sense of a vast increase in population, wealth and importance, then surely this increase is to be effected through the agency of "the men who do things" or the engineers, and in my mind, there can be no overproduction of engineers provided they be well equipped by a proper training along the broad lines of engineering suggested.

We must bear in mind that the opening up and developing of a new country with its consequent requirements in public works and industries of all sorts is not effected by the lawyers and the physicians (important as these professions may be), and we must see to it that our educational institutions are kept alive to the requirements of modern civilization, the necessary education for which is no longer crystallized in ancient books written in the dead languages.

To my mind this means that many of you must be prepared to take up mining, metallurgical, electro-chemical, and other industries which are best managed by the educated engineer, and that there is ample work for an immense number of men educated along the lines indicated in Canada. Consider our advance in mining alone. The mineral production of Canada in 1886 was $10,221,255; 1896, $22,474,256; 1906, $79,057,308; 1909, $90,415,763, or $12 per capita, as against $2.23 per capita in 1886—and we have just begun.

Northern Ontario and Quebec have scarcely been glanced at as yet by the prospectors, yet you are all familiar with the fact that Ontario produces the bulk of the world's nickel and about 12 per cent. of the world's silver and much of its corundum and mica. Quebec produces most of the world's asbestos.

Our prairies and British Columbia contain the coal that is

essential for the existence of the population flowing in there, and for the North Western United States.

We have many hundreds of miles of the same rocky mountains that have produced all the fabulous wealth in silver, gold and copper, in South America, Mexico, and the Western United States. In Canada the development of these undoubted mineral resources is comparatively slow, owing to climatic conditions in winter and the general distribution of forest growth owing to the moister climate—meaning so much greater things for the ultimate welfare of the country.

Here we see forest growth and forestry entering into the domain of engineering and raising the question of how nearly allied is the science of forestry and the conservation of other natural resources to our profession. Here are a few figures to measure the question by: In 1887 I built a large coal-loading wharf in Nova Scotia, the hemlock timber for which cost $4.50 per 1,000 feet B.M., sawn in bridge sizes and loaded on cars. It had been cut down for the tan bark, a part of what would otherwise have rotted in the woods was utilized for the wharf. The present price of such timber there would probably be $20 per 1,000. About 1891, in Parry Sound District, white pine hewn to railway bridge sizes was delivered at the site of the structures for $7.50 per 1,000 feet B.M. During the past two years nearly all the timber of the same sizes required for the mining buildings in Cobalt has been brought from British Columbia at a cost of about $27 per 1,000.

The "inexhaustable" pine forests of Canada are of the past as our other forests will shortly be if we do not take extraordinary precautions towards conserving and replanting them. A recent fishing trip in the northern portion of Quebec impressed me with the importance of the work being done in this respect by our professional ancestors, the beavers. They have been protected there for some years, and have increased until they are very numerous and have flooded every old-time dry beaver meadow and raised the level of every pond and small lake from two to four feet. In the aggregate this must have an important effect in checking forest fires and conserving and regulating the flow of water in the rivers, and benefiting the conditions desirable for the operation of water powers.

Coincident with the increased cost of timber we find a decrease in the cost of Portland cement of much superior quality which is rapidly taking the place of timber in many structures.

When reinforced with steel we get a most important new building material, the proper use of which is an art almost worthy of forming a separate branch of Civil Engineering.

Concrete is beginning to be used in ship-building. Barges of reinforced concrete are said to be in use in Europe, and it is said that one is being designed to be built in Ontario. It would appear that the design must be very simple, or the cost

for timber forms will be excessive. The economical use of lumber for forms for concrete structures and the design of structures to this end, forms a subject well worth much more attention than has generally been given it to date.

To return to this very important subject of transportation, which a few years ago engaged almost solely the engineering skill in Canada.

Beginning about a century ago, the rapids of the St. Lawrence were canalized for small boats, and a similar canal was built at the Sault by the Hudson Bay Company. Then followed continuous enlargements, the construction of the Welland Canal begun early last century by private enterprise and afterwards enlarged by the Dominion Government, until Canada has transportation facilities for ships of over 2,000 tons carrying capacity through the greatest canal system in the world right from the Atlantic to the head of Lake Superior equally free to ships of all nations.

During the past few years the Dominion Government has had surveys made of the proposed Ottawa ship canal to take ocean ships from Montreal up the Ottawa and Mattawa Rivers to North Bay, and down the French River to Lake Huron, at an estimated cost of over $100,000,000. It would appear to me that this should be the next large national public work to be undertaken so soon as the country has the National Transcontinental Railway completed and satisfactorily financed. Its construction will be warranted as a transportation route, to say nothing of the value of the water powers to be developed thereby, and its value for defence purposes. As a comparison, consider the cost to the State of New York of $150,000,000 for the enlargement of the Erie Canal to carry barges of 1,000 tons only from Buffalo to Troy.

Our western country is greater and of more value, I believe, than that of the United States.

In railway work the Grand Trunk was the pioneer and served the southerly portions of Ontario and Quebec exclusively for many years. Then followed the Intercolonial, forming a bond of union with the Maritime Provinces, thus making possible the consolidation of the Easterly Provinces within one Dominion.

One of the terms of the Confederation of British Columbia with the Dominion was the early construction of the Canadian Pacific Railway, which had been started as a government measure in the seventies. The Canadian Pacific Railway represented by a syndicate of leading Canadians, undertook the work early in the eighties, and in a remarkably short space of time, completed the laying of the rails to the Pacific in 1885, at a time when many of the people of this country declared it would never earn enough money to pay for grease for the axles. I was on the construction of that road north of Lake Superior when the "syndicate" had exhausted its means, and for about six months

we, the engineers, got no pay. Now the earnings of this, the greatest railway system in the world under one management, is close to $2,000,000 per week.

Now the National Transcontinental Railway is being constructed, duplicating our railway transportation facilities from Moncton, N.B., to the Pacific, at a distance to the north of the Grand Trunk and Canadian Pacific through Ontario and Quebec that is giving that part of Canada a width from north to south undreamed of a few years ago.

The Canadian Northern Railway is another road which in a few years will be a third transcontinental highway for Canada, the country that 25 years ago was estimated by many of our people as being unable to pay for grease for the wheels of one. At that time many of our people were leaning strongly towards "commercial union" or "annexation" with the United States as our only salvation from financial ruin.

I have been reading "The Valour of Ignorance," by Major-General Homer Lee of the U. S. Army until I am almost a believer in annexation myself, the annexation of the United States to Canada. Read the book, it will repay you.

This Canadian Northern Railway is being built by two Canadians who started in life without any special educational or other advantages than industry, any amount of pluck and an abiding faith in the future of this country. Now they are probably the greatest railway owners in the world, and bid fair in a few years to own as a partnership of two a complete transcontinental railway of several thousands of miles, to say nothing of their other enormous interests, street railway, mines, steamships, and other engineering works.

In water power development Canada ranks almost first with nearly a half-million horse-power developed or being developed in the Niagara District alone. Consider the value of this to the territory served by this power by comparing its cost at, say, an average of $25 per horse-power per year for 24-hour service to the consumer as against the cheapest other available power, the gas engine at, say, $50 per year, or the steam engine at any price from $75 per year to $150 per horse-power per year.

In 1893 I had charge of the construction of a very large (at that time) hydro-electric plant at Niagara Falls, Ontario, for the Park & River Railway Company. We developed 2,000 horse-power and the best electrical authorities advised that it was cheaper to put in and operate a steam engine and generator at Queenston to operate cars on that grade, 12 miles from the power-house at the Falls, than to convey the current from the main power-house. It was put in and operated for some years. Now we see that same power being carried a couple of hundred miles at 110,000 volts. Have we reached the limit?

Well, the subject of engineering is so wide and Canada is so big and so full of opportunities for any one who is indus-

trious that were I gifted as a speaker I could continue along this strain till you are all asleep.

However, I will close with another word of warning:

We are rapidly acquiring much desirable national wealth and are no longer a small number of poor people struggling for a bare existence along a northerly fringe of the United States, as we were a few years ago.

As our national wealth increases and our importance is recognized by other nations, we become more subject to the envy of those countries in Europe, Asia, or America, whose populations are sufficiently dense to desire room for expansion, and we must therefore be prepared to defend our property unless we are content to become a conquered people subject to laws and customs which are alien.

This may seem to many of you as far-fetched or exaggerated .Again, I advise you read "The Valour of Ignorance," by Homer Lee.

Let me call your attention to the words of Mr. L. S. Amery, Colonial Editor of the London Times in an address at the Canadian Military Institute the other day.

"We do not," he said, "consider the work of the sanitary engineer or the physician in defending the community or the individual against disease as unproductive or unnecessary, or the work of the teacher in defending the child against ignorance, or that of the clergyman in defending his people against immorality, or of the lawyer in defending his client against imposition and injustice, as unproductive and unnecessary work. Neither should we consider the work of the nation in providing munitions of war or the work of the soldier in preparing himself by study and training to defend his home and country as unproductive work. All these are essential to national existence and to national development."

He believes that it was the duty of every able-bodied citizen to prepare himself to defend his country. "A nation that looks after the physical, intellectual and moral development of its people by means of the necessary military training will solve all of its other problems. Its industrial and commercial efficiency will be enhanced because of the patriotism and capabilities of its trained manhood. Perhaps a few people say that Canada has no need for a defence force, that Great Britain will defend this country, or this nation can lean on the United States; surely Canada does not desire to be a parasitic nation. She does not, and will not, wish to lean on anyone."

Some men who have not studied the subject have declared that Canada need not bother about means of defence, as the United States with her "Munroe Doctrine" will protect us.

As Homer Lee points out, "In the time of Munroe, it was impossible to foresee the changes mechanical inventions were to make in the political development of the world after his time.

No longer, as in Munroe's time, does a vast Atlantic separate this continent from Europe. Man's ingenuity has reduced it to a small stream, across which the fleets of European powers can cross in less time than it took Munroe to post from Washington to Boston."

He speaks in the same strain of the Pacific Ocean, and points out the imminent danger of a Japanese conquest of the Western United States, owing to the absolute commercialism of our neighbors to the south, and their neglect to take the necessary precautions of defence.

Assuming that some military and naval force be necessary to the existence and welfare of this country, we live in a too democratic age to permit a small number of our men who are sufficiently patriotic to spend their time, means, and possibly their life's blood to defend the others who sit at home in ease and—for a small price paid in taxes—enjoy the privilege of reading these things in the daily papers.

I do not wonder at the agitation for woman suffrage. Have they not as much right to vote as their brothers who refuse to take a man's part in being trained for the defence of their firesides?

Apart from all military considerations, every engineer who may have to do with organization of forces of men, or of a staff to direct any operations in the engineering profession, will find that the discipline which can be learned only in military life gives a very important advantage over his competitor who has neglected his opportunities along this line.

I know many will say "There is no time. All the time we can spare from study is taken up in music, or football, or cricket, or the gymnasium:" These are all good, but to my mind, they do not compare with the military training which is as important as mathematics.

I am pleased to know that the University has one military organization, a field company of Engineers, which trains about one hundred men.

We should have every man in the University who is physically fit enrolled and given the opportunity of learning to obey before he is called upon to command and of obtaining the first principles of a training that will fit him to help to defend when necessary this Canada of ours, and to keep it for all time a part of the greatest empire the world has seen.

You may find, as do most engineers who stick to the purely professional side of the work, that the prizes in the profession are few and not very large when compared with responsibilities and the labor; but when all is balanced up, you will be able to say you have lived a man's life among men, and have done something that has left its mark on the development of your country, and have been of service to your fellowmen.

NOTES ON THE ELECTRO-METALLURGY OF IRON AND STEEL.

T. R. LOUDON, B.A. Sc.. A. M. Can. Soc. C. E.

Although the electric furnace has been used in the metallurgical industry for a considerable period of time, it is only within recent years that it has been possible to successfully produce pig iron and steel on a commercial scale. At the present day, the problem of mere mechanical operation seems to have been solved, so that it is only a question of efficiency and cost of electric energy as compared to ordinary fuels that determines the commercial value of the electro-thermic process for any given locality.

It will be the endeavor in this article to explain concisely the working of a few of the different furnaces used in the electro-thermic reduction of iron ore and the subsequent production of steel. It is, of course, understood that the accompanying drawings are extremely diagramatic. They will, however, serve very well the purpose of illustrating the theory embodied in each process. Should the reader care to go more fully into the question, there will be found throughout this article reference numbers, the key to which is given at the end.

Before discussing the various processes, it is extremely important to understand the part that electrical energy plays in the production of either pig iron or steel. In the ordinary process of smelting, the ore, together with limestone and coke, is dumped into the blast furnace, and as the result of certain chemical reactions that take place, pig iron is produced. Stated in as simple a manner as possible, the hot coke at the lower levels in the furnace meets a blast of air, and the ultimate result is that there is a formation of carbon monoxide gas. This gas, together with the carbon of the coke, reduces the iron from the ore. Now it is a matter of common knowledge that it would be impossible to bring about this reduction of the iron if the process were not carried on at a high temperature, and in order to attain this temperature, a certain percentage of the coke in a blast furnace is there for the purpose of producing heat. So then it is seen that the coke is present for two definite purposes: (1) To provide an agent with which to reduce the iron from its ore (2) as a source of heat. It is for this last purpose that electric energy is used; i.e., as a source of heat.

Working on the basis that the requisite heat is to be supplied by electrical means, if the cost of electrical energy required to give the same amount of heat as a ton of coke be figured out, it will be found that the price of coal for coking would have to be extremely high, and electric power very low before one could ever hope to replace the former with the latter. This calculation, however, takes no account of the fact that

electric furnaces are far more efficient in their utilization of heat than furnaces using ordinary fuels. When these efficiencies are taken into consideration, it is found, roughly speaking, that with electrical power costing ten dollars per electrical horse-power per year, and coal at about eight dollars per ton, the electric reduction furnace may compete successfully with the ordinary blast furnace. These figures are, of course, the extremes in cost, but there are many localities where such conditions exist. (Reference No. 1 and 2).

As in the making of pig iron, so with the processes for making steel; the electric current is the means of providing heat. The ordinary furnaces for making steel, however, are far less efficient in their utilization of heat than the blast furnace, so that the electric steel furnace with its high efficiency is able to compete with some of the other processes under the ordinary commercial conditions. This is especially true where the electro-thermic process is used in conjunction with the ordinary processes.

Electro-Thermic Reduction of Iron Ore.

Roughly speaking, the reduction furnaces in use at the present time may be divided into two classes; those with vertical electrodes embedded in the charge; and those with the electrodes projecting into a crucible at the lower part of the furnace. Both of these types are known as "resistance furnaces," due to the fact that the heat is generated by the resistance offered to the passage of the current through the charge.

The simplest form of furnace is that shown in Fig. 1. The carbon electrode A is suspended by some regulating device in

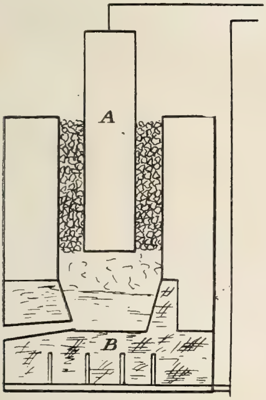


Fig. 1

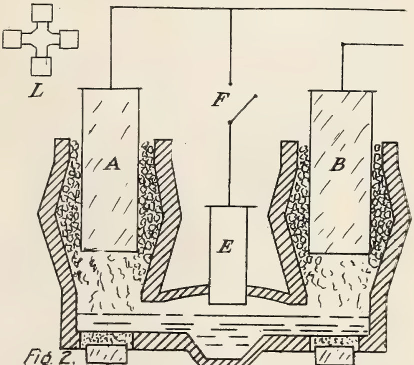


Fig. 2.

the charge of ore, coke and limestone. The crucible walls and the hearth are made of a carbon paste, in which is embedded a second electrical connection, C. If, now, the circuit be closed, the current in passing from A to B, or vice versa, will, owing to

the high resistance of the intervening charge, develop the necessary heat requisite to attain the desired temperature.

A furnace of this type was successfully used in the experiments carried on at Sault Ste. Marie by the Canadian government under the direction of Dr. Haanel. While these experiments were entirely satisfactory, it was pointed out on their completion that there would have to be some modifications made in order to allow the charge to feed regularly and to utilize the gases as they escape from the top of the furnace. An attempt was made at the time to make use of these gases by introducing an air jet into the charge near the top, thus burning the gases, but it was found that the charge became sticky, and was inclined to "hang"—a very bad fault. (Reference No. 3).

Fig. 2 represents a type known as the Keller furnace, invented by Mr. C. A. Keller of France. A and B are two carbon electrodes. Embedded in some conducting material in the hearth are two electrodes, C and D, connected together as shown. To begin operations, A and B are lowered and the charge packed around them. At first, the path of the current will be from A down the charge, across from C to D and up the charge to B, or vice versa. As soon as the iron covers the hearth, however, the current instead of passing around the shunt from C to D, as described, will take a path through the molten metal, thus tending to keep it warm. Sometimes, though, the bath may cool at the centre. If this occurs, the auxiliary electrode E is brought into play by closing F, part of the current then passing through the central portion of the bath, giving a greater intensity in that locality.

This furnace may be built with a plurality of hearths, as indicated at L, Fig. 2, each of the small squares representing a stack with its vertical electrode. By this arrangement the electrodes may be arranged in pairs in parallel if so wished, thereby giving a better system for regulation. (References Nos. 4 and 5.)

Leaving for the time being the discussion of these vertical electrode types, there are shown in Figs. 3 and 4 two furnaces of the second class indicated previously.

Fig. 3 shows diagramatically the construction of a furnace which is the outcome of a number of experiments carried on at Domnorfvet, Sweden, by Messrs. Grönwall, Lindblad and Stalhane. A number of different furnace shapes were tried until finally the construction indicated in Fig. 3 was arrived at.

The upper portion of the furnace is in appearance very much the same as an ordinary blast furnace. This shaft is built on a large crucible or melting chamber, B, projecting through the roof of which are three electrodes, one being shown at A. At the top of the shaft, there is, of course, a cover with a charging bell very much the same as on the present-day blast furnace. The gases coming off the charge at the top are led out at C to

a dust catcher, D. Cleansed to a certain degree, this gas is blown by means of a blower, E, back into the crucible at F.

It will be noticed that the tuyeres by means of which the gas is blown into the crucible slant upward. This is for the purpose of allowing the gas to impinge against the crucible roof, thereby cooling it. This does not in any way lower the efficiency of the furnace, the heat absorbed by the gas in cooling the roof. being given back to the charge as the gas flows upward again. Indeed it would appear to be a great factor in raising the efficiency, since the heat absorbed by this gas in the crucible would have otherwise been most likely lost by radiation. The tuyeres

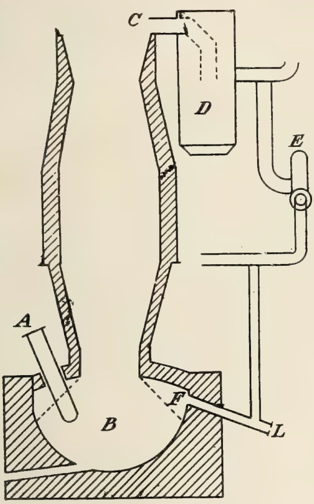


Fig. 3.

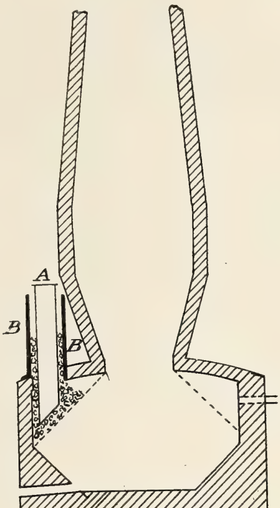


Fig. 4.

(three in number) by means of which this operation is performed, have peep-holes, as shown at L, so that the operator may judge the roof temperature, and accordingly regulate his jets of gas.

In this process there are no electrodes embedded in the walls of the furnace, the current passing between the three projecting carbons, thus giving intense heat in the crucible.

The Frick furnace, shown at Fig. 4, is somewhat similar in construction to the last furnace. A vertical shaft is superimposed upon a crucible, and through the roof of this lower melting chamber there project two vertical carbon electrodes, one of which is shown at A. These electrodes are suspended in casings or shafts, shown by heavy lines at BB.

The distinguishing feature of this furnace is the fact that the electrodes are packed around loosely with a reducing agent such as coke or charcoal. This coke or charcoal forms a protecting layer around the portion of the electrode in the crucible, and

also intervenes between the electrode and the charge as indicated. (The dotted lines represent the slope of the charge as it works down from the shaft).

The purpose of providing this covering of coke or charcoal, as the case may be, is to protect the electrodes from being oxidized away. It can readily be seen that the carbon of the electrode would itself be oxidized if there should happen to be quantities of ore around the electrode. The reducing agent, however, protects the electrodes from being oxidized by entering into the reactions itself, and also since there is an intervening layer between the electrode and charge, there will be far less wear on the electrode, as the charge slides down.

There is also provision made in the furnace to carry the gas from the top and blow it back into the crucible if it is so desired. (References 6 and 7).

Electric Steel Furnaces.

Furnaces in which the refining action necessary for the production of steel may be carried on can be divided into two classes: (1) Induction Furnaces; (2) Arc Furnaces. The latter class can be sub-divided into furnaces in which the arc is formed between the electrodes above the bath; and those in which the arc is between the electrodes and the bath.

Furnaces of the induction type are constructed in such a manner as to make use of a well-known electrical principle which may be stated to suit this particular purpose as follows: If an alternating current be passed through a coil of wire known as the primary coil, and if there be surrounding this coil a second

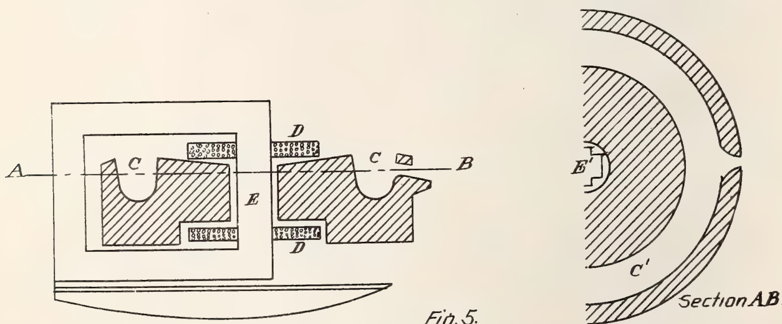


Fig. 5.

independent coil, there will be induced in this secondary coil, as it is called, an independent alternating current. In order to intensify this effect it is usual to wind the primary coil around an iron core.

Fig. 5 represents two sections of one of these induction furnaces. At D and D are two coils of wire wound on an iron core, E. Surrounding this core is a circular channel, sections of which

are shown at CC. If a horizontal section, AB, be taken, the channel will appear as at C′, surrounding the core E′. (Merely half of this section is shown).

If now the channel CC be filled with a charge of molten iron, there will be formed around the core and coils DD a closed coil of one turn; so that if an alternating current be passed through the coils DD, there will be induced in the molten metal another independent current. It is this induced secondary current that furnishes the heat in the charge forming the ring CC.

There are a number of these induction furnaces being used for the manufacture of high quality steel. The particular type shown diagramatically in Fig. 5 is known as the Frick furnace; but there are several other types, outstanding among which are the Kjellin and Röchling-Rodenhauser. In the Kjellin furnace, there is merely one long vertical coil around the core instead of the two flat coils as in Fig. 5. There are, of course, other differences, but the explanation given for Fig. 5 will apply to the Kjellin furnace, which has a channel around the primary coil for the charge. (References 5 and 11).

The Röchling-Rodenhauser furnace, while it is of the induction type, has a feature which is extremely novel. This furnace may be said to have two secondary currents, one of which is the usual current induced in the ring of metal as explained before. The other current has its source as follows: Around the primary coil is placed a secondary wire winding, the terminals of which are led to electrodes embedded in the walls of the channel for the metal. Thus there is induced in this secondary winding a separate current, which in passing through the bath of metal adds to the heating effect of the current already induced in the ring of metal itself.

Unfortunately, it is impossible in such a synopsis to go more completely into the details of these furnaces, but there will be found in References 5, 7 and 8 abundant information regarding the three types mentioned.

Passing to the arc furnaces, at Fig. 6 there is illustrated the principle of the Stassano furnace. Projecting through the walls of the furnace are three electrodes, as shown in the cross section. Between these carbons is formed an arc, A, the heat from which is radiated to the bath of molten metal B. The furnace, which is inclined, is given a rotary motion about its upright axis, thus causing a stirring of the charge. The regulation of temperature in such a furnace is under very easy control. (References 5 and 9).

Considering next furnaces in which the arc is formed between the electrodes and the bath, there are two types which seem to stand out pre-eminently, viz., the Héroult and the Girod furnaces, the principles embodied in both being easily explained.

Fig. 7 illustrates the method of making steel in the Heroult

furnace. Suspended through the roof of the furnace are the electrodes A and B. The charge lies on the hearth and these electrodes are lowered till an arc forms between them and the bath. The current passes down one electrode, arcs to the bath, goes through the bath, arcs to the other electrode, and out again.

The upper cross section, Fig. 7, merely shows diagramatically that the furnace is so constructed to allow it to be tilted forward when the charge is to be withdrawn. The electrodes are held in position by braces attached to the furnace as indicated. (Reference 5).

The Girod furnace, while it is in outward appearance very much the same as the Héroult, differs from it in this respect.

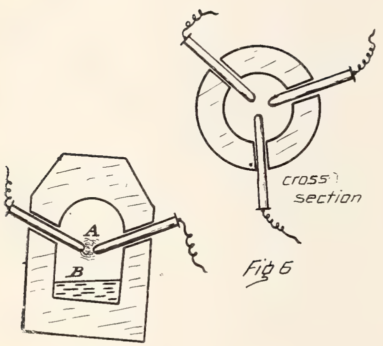


Fig 6

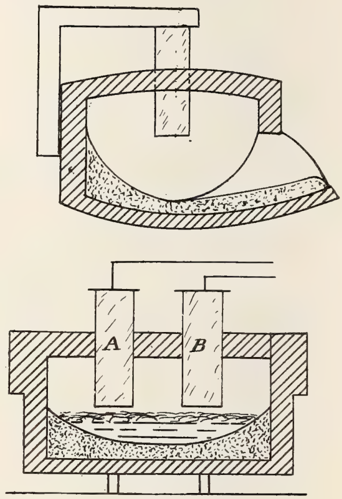


Fig. 7

Embedded in the hearth of the furnace are suitable electrodes, and the current, instead of passing in and out from the top carbons as in the Héroult furnace, has a path from the upper electrode, or electrodes, through the bath to the connections in the bottom of the furnace. Thus instead of the upper carbons being in series, as in the Héroult system, they are in parallel. In actual operation, the current in the Héroult furnace passes along the slag, thus providing a very hot blanket as it were. In the Girod system, the current in passing through the bath itself gives, it is claimed, a method more suited to working from a cold charge. As against this is the counter-claim that furnaces with electrodes embedded in the hearth are troublesome to repair. Be all this as it may, there is the incontrovertible fact that both systems are now in extensive use. (See reference 10).

In conclusion, it is interesting to note that not only are these steel furnaces being used to displace the old inefficient

crucible steel plants, but there are notable examples where the larger fields have been entered. Quite recently the Prussian state railways have been buying rails from a firm manufacturing steel by the Röchling-Rodenhauser system. These rails when tested chemically and physically were of a much higher standard than the specifications called for. In the United States the Illinois Steel Company has lately been refining molten steel from the acid Bessemer process by means of a Héroult furnace. There are also other instances where the electric furnace is being used in combination with either the Bessemer or Open Hearth processes as will be seen in Reference 10.

In Reference 10, there will be found a tabulated list of steel furnaces in use throughout the world. It will be noticed that in most cases alternating current is used—mostly single phase—although direct current is sometimes used. The reduction furnaces described use an alternating current.

As to the actual working of these electric furnace processes, it may be pointed out that the regulation of the metalloids in the desired metal follows the theory of the ordinary processes, the main difference being that it is possible to maintain very much more basic slag.

SUMMARY.

The advantages of the electric furnaces, reduction and refining, may be stated as follows:

1—Efficient production of heat.

2—Ease of regulation as regards temperature.

3—On account of the high temperatures attainable, it is possible to maintain a very basic slag.

4—Absence of injurious gases in steel working processes.

5—The possibility of using charcoal as a reducing agent for making pig iron.

KEY TO REFERENCE NUMBERS.

No. 1—The Electric Furnace, Its Evolution, Theory and Practice (Alfred Stansfield).

This book contains a very concise and clear outline of the historical development of the electric furnace. There will be found in it a discussion of the relative costs of electric energy and fuel for producing heat.

On page 250, vol. 13, of the *Canadian Engineer* will also be found a discussion of these relative costs by the same author.

2—"Metallurgical Calculation," vol. 1 (J. W. Richards).

The methods outlined in this book are extremely good.

3—Report on experiments at Sault Ste. Marie, 1907 (Eugene Haanel).

These experiments were carried on by the Canadian government.

4—Application of the Electric Furnace in Metallurgy (A. Keller).

Journal of Iron and Steel Institute, 1903, vol. 1, page 161.

5—Report of the Commission appointed to investigate electro-thermic processes of smelting iron ore and making of steel (Eugene Haanel).

This is the most comprehensive report ever made on electric processes up to 1904, and is even yet invaluable.

6—Investigation of an electric shaft furnace, Sweden (Haanel).

7—Recent advances in the construction of electric furnaces, etc. (Haanel).

The last two reports published by the Canadian government are very complete.

8—Electro-chemical and metallurgical industry, vol. 6, pages 10 and 458.

Good descriptions of the Röchling-Rodenhauser furnace and its operation.

9—Same periodical as 8, vol. 6, page 315. This is an exhaustive article by the inventor of the Stassano furnace.

10—Stahl and Eisen, March 23, 1910, page 491.

This gives a tabulated list of furnaces in use. See also No. 7 for same thing.

11—A description of a Kjellin furnace will be found on page 397 of vol. 3, journal of Iron and Steel Institute.

PROSPECTING IN THE COBALT DISTRICT.

H. L. BATTEN, '11.

Prospecting covers a great many operations, from the search for, and staking of claims, to actual mining work underground. This paper does not deal with the search for claims, but is an attempt to give some idea of the work to be performed after the claim is staked, for the purpose of determining the value of the property, position and value of veins, etc. We are still left with surface prospecting and underground work to be considered, as both have to be performed in practically all cases before a property may rightly be called a mine. There can be no doubt that a thorough prospecting of the surface before commencing mining operations is of the utmost importance, and should be taken seriously. In spite of this fact there are quite a number of properties around Cobalt and South Lorraine with a shaft down 100 feet or more on a one-inch vein of calcite carrying no values, while not a shovelful of dirt has been moved on the other parts of the property. The cry is, "We have no money to spend on the surface, and besides, all the veins do not show on the surface." This is no doubt true, to a certain extent, but if we try to make out a list of paying mines around Cobalt that had no showings on the surface, we shall find there are very few.

Again, a great number of the properties that are supposed to have been prospected have never been prospected thoroughly. The work has been done in a haphazard manner by the original owners, or by men hired by them, as assessment work. The idea has been to put in so many day's work, and no successful prospecting can be carried out in this manner. For the work to be thorough, some system must be adopted, not necessarily to be blindly followed, without modifications, but to serve as a guide. Unless some method is adopted, trenching will not have progressed very far before the question "where to put the next trench" will arise. Again, if the positions of the trenches be determined before work commences, it will probably soon be found that a trench could be run, with much less work, a few feet to one side, and be of equal value for prospecting purposes.

The idea of surface work is to lay bare the bed rock, so that it can be examined. This is usually done by digging parallel and perpendicular trenches, thus dividing the property into a number of squares or rectangles. The distance between the trenches must be determined by the circumstances. The closer the trenches the less likelihood of veins being missed, but a great number of things have to be considered. If the surface covering is deep it may not be advisable to run trenches less than 200 feet apart on account of the expense. On the other hand, the Nipissing Mines intend to remove all the surface covering by hydraulicing.

It is obviously impossible to lay down any rules, as the distance between trenches must be determined only after considering all the circumstances; but on most properties probably about 60 feet apart would be a suitable distance. The distance apart will probably not be the same all over the property. It may be found after putting down a few trenches that, while part of the property should be prospected very carefully, the remainder may not show indications of being worth going to much expense over. No hard and fast rules can be laid down.

As regards the direction of trenches, the usual way is to run north and south, and east and west trenches. When no veins are known on the property, and the surrounding properties have not been prospected, these directions are as good as any, and are most convenient. However, it is a somewhat generally accepted rule that veins in proximity to each other are likely to be approximately parallel. The best direction, therefore, to run the first trench is perpendicular to a vein that has already been uncovered. There is almost sure to be such a vein, marked by a discovery post, and a start should be made at that vein. On a property prospected by the writer this last summer, one vein was known before commencing to prospect, striking approximately north and south. By running trenches perpendicular to this vein four others were uncovered, their strikes varying from north and south to north 50 degrees east. Thus the strike of a vein probably is an indication as to how nearly veins may be expected to run; but veins are extremely erratic, and are almost as likely to be found running in any other direction.

The first thing to be done in prospecting a property is to find out everything possible about it; assuming, of course, that everything possible has already been found out about the company working it. The boundary lines should be carefully and clearly marked out or a great deal of time will be wasted hunting up corner posts. The whole property should be gone over carefully, in company with a man who knows the ground, if possible. If time permits, a rough sketch map should be made, showing the relative positions of any veins that may be known, outcropping rock, swamps, or other places difficult to prospect, and as much of the geology as can be determined. If the timber has been cleared off, this work should not take long, but if the bush is thick a week probably can be profitably spent in this manner.

It is necessary to be fairly well acquainted with the property before deciding on the best way even to start prospecting, or where to start, so that the work may be put in to the best advantage. A little care and forethought can save money in prospecting as in everything else, and no start should be made until the whole claim has been carefully examined. There is always some doubt where to make a start. If the vein on which the discovery was made has not been stripped, three or four men (not

more than four men can work to advantage, stripping a vein that has been uncovered in only one place), should be put on this job while the claim is being examined. This vein should be stripped for a sufficient distance to give a good idea of its value. If the indications are promising, it (and all the veins) should be stripped as far as it can be followed. However, as soon as the approximate strike has been determined, more men can be taken on and a trench started perpendicular to the vein; or approximately so.

The property will probably be divided naturally into several sections. The goal to be aimed at is to show results in the shortest possible time, and work should therefore first be done where the indications are best; or if there are no indications worth considering, a start should be made where the most bed rock can be stripped in a day. The section containing the vein should be the first to be prospected, and an attempt must be made to pick up any parallel veins there may be.

Contacts must be considered. If diabase outcrops in one place and Keewatin rocks in another, they should be joined by trenches, and the contact located. The reason for this is that there is a likelihood of veins occurring at or near the contact. In the case of the five parallel veins referred to previously, the first was at the contact of diabase and conglomerate, while the other four were all within 250 feet of the contact.

In working over the ground in sections however, care must be taken not to lose sight of the general method which has been adopted. Before the work is complete the trenches in the different sections have to be connected up, so that each trench runs from one boundary line to the line opposite. This may not be possible on account of a swamp or drift too deep to make trenching practicable, but should be carried out whenever possible.

Where heavy trenching is encountered it should be left until all the light work has been done, unless there is some special reason why it is desirable to put down a trench in that particular place. When to leave a trench (temporarily, of course), is a matter of judgment. As a general rule it may be said that all trenches requiring timbering should be left till the lighter work is finished. In the spring no attempt should be made to put down wet trenches—it is almost hopeless to try and make sure of missing no veins and yet make good progress with wet trenches. Also, it is impossible to make good footage with heavy or wet work, and it is most important to make a good showing at the start.

Before settling down to prospect thoroughly, section by section, the whole claim should be gone over by running a few preliminary trenches. This is especially advisable if outcropping rock be scarce. As accurate a map as possible should then be made, and on this map everything that is known should be marked. This map should be carefully made and brought up to

date at least at every month-end. The positions of all trenches should be accurately shown, and the positions of all veins and test-pit marked. When a few trenches have been put in, the topography should be sketched in, and the elevations of all important points shown. The only instruments required are a compass and chain, and an aneroid barometer, for obtaining the relative elevations. This map is useful for several purposes. It can be seen at a glance what ground has been prospected and what remains to be worked, and the required positions of trenches to connect with trenches already dug can be determined. If the bush is thick these cannot be lined in by sight. Also reports on the progress made are greatly simplified by the possession of such a map. A tracing can be made each month-end, with each month's work shown in different colors, and handed in with a short description of any discoveries made. Such a report conveys more information and creates a better impression than a lengthy written account of the work performed.

There are a few points to be noticed regarding the details of the work, and one of these is the best widths for trenches. It must be remembered that a slight increase in the width of trenches means a considerable increase in the amount of dirt to be shovelled. Economy therefore, demands a narrow trench. In a narrow trench, however, it is very difficult to clean off the bed rock thoroughly. Three feet in width should probably be considered a minimum, and this width is sufficient only for trenches up to about three feet deep. A trench five feet deep should be four feet or four feet six inches wide on the surface, and deeper trenches, even if no timbers are required, should be wider still. The best width depends to a certain extent on the banks, so it is impossible to lay down any rules, but the general tendency is to dig trenches too narrow, which means difficulty in examination, and a consequent likelihood of veins being passed over unnoticed.

As bed rock is stripped it must be very carefully cleaned off. If the surface is dry sand or gravel, this is best done by brushing. If the soil sticks to the rock, as clay, for instance, does, the rock must be washed, and washed thoroughly. Care must be taken not to fill up the cracks and crevices with mud, as it is these which have to be most carefully examined. It is better not to wash off the rock unless absolutely necessary, owing to this trouble caused by the inequalities being filled with mud.

Trenches cannot be prospected too carefully, as especially in diabase, it is often extremely difficult to recognize a vein. The bed rock should be most carefully watched for any change in texture, as the rock near a vein is often finer grained than the surrounding rock. Too great care cannot be exercised, and every place where there could possibly be a vein should be shot out. The number of veins which have been found in old trenches, and which had previously been missed is startling.

With even the greatest care some small veins will probably be passed over, and a vein less than one inch in width in this district may be extremely valuable.

Having found a vein, the amount of work that should be done on it depends on the vein itself. It must at least be stripped for some little distance, and a test pit sunk deep enough to get below the weathered surface. If the indications are in any way promising it should be stripped and opened up as far as it can be followed, and the trench should be sufficiently wide to allow the vein to be shot out without having the banks fall in on it. A considerable amount of shooting is unavoidable when opening up a vein, but as much drilling as possible should be avoided, since it is extremely difficult to get a hole down to any depth owing to the number of joints and seams usually found near a vein, and even under the best conditions, drilling is a slow and expensive job. A vein can usually be opened up by exploding powder in the fissure (providing the loading and tamping be properly done). More powder will be used than with drilled holes, but the saving in labor more than repays for this.

Before reporting any find, care should be taken to be absolutely certain. If in very small pieces, bismuth and silver are easily confounded. When looking at museum specimens there appears to be little similarity between the two, but when silver is expected and a speck of bismuth encountered, it is very easy to be misled, in fact, it is often absolutely impossible to be certain without a chemical test. Cobalt bloom and red iron oxide are frequently confounded. Unless there can be absolutely no doubt a chemical test should always be made before any find is reported.

When the surface work is completed there are two methods of prospecting underground to be considered—the ordinary mining methods, of shaft-sinking, drifting and cross-cutting; and the diamond drill.

It can safely be said that the diamond drill has not been a success in this district, at least as far as the search for, and testing of veins is concerned. There are two principal reasons for this failure; first, as the drill passes through the vein the latter breaks up into powder, and no core of the vein-matter is obtained. Secondly, even when a sample of the vein is obtained, the information gained is of little value. Only one point in the vein is sampled, and while there may be no values or very low values just at that point, other parts of the vein may carry high values. Sufficient data to form any idea of the value of a vein cannot be obtained with the diamond drill.

Ordinary mining methods apply to shaft-sinking, etc., whether the property is a prospect or a mine. It is obviously impossible in this paper to go into such questions as to when a plant should be installed, or when to work by hand. Around Cobalt this question has been solved to a great extent by the

advent of the power companies. In South Lorraine it still exists, although they are expecting to have electric power there this fall (1910).

It must be remembered that in prospecting, as in all mining ventures, no two propositions are alike. The work to be done depends upon so many things; the property itself, amount of money to be spent, the length of time in which to perform the work, and a host of other circumstances have to be taken into consideration. There is room for differences of opinion at every turn, and there is no pretence made that this paper is in any way complete, or even representative, it is simply a collection of a few opinions formed during a couple of summers' prospecting in Cobalt and South Lorraine.

GAS AND OIL ENGINE RESULTS.

Thermodynamic Laboratory, University of Toronto.

W. W. Gray, B.A. Sc.

A series of tests was conducted by a party of fourth-year students, Messrs. Schwenger, Stroud and Thompson, on the 9 B. H. P. Fielding and Platt gas engine, to determine its gas consumption per B. H. P. per hour at various loads.

The engine is of the single cylinder, single acting, horizontal, hit-and-miss governor type, and is of standard English design throughout. The results obtained are very satisfactory for an engine of this small power.

Results of Tests.

City illuminating gas.
Diameter of cylinder, 7 inches; stroke, 14 inches.
Compression, 90 pounds per square inch.
Ignition, electric, by trip magneto.

No. of test	1	2	3	4	5	6	7	8	9	10
Date	Jan 25	26	26	26	26	26	27	28	28	28
Duration (minutes)	40	30	30	30	25	30	25	30	15	30
R.P.M.	220	220	219	219	219	220	218	218	218	218
B.H.P.	0	1.19	2.03	3.04	4.05	5.08	6.04	7.06	8.06	9.07
Gas per hour, cu. ft.	51.2	91.5	86	93	114	121	150	153	166	182
Gas per B.H.P. hour cu. ft.		76.9	42.4	30.6	28.1	23.8	24.8	21.7	20.6	20.1
Ratio — Gas	1	1	1	1	1	1	1	1	1	1
Ratio — Air	9	6	10	10	10	12	10	10	10	10

This engine is provided with a special vaporizer and valve gear, to allow the use of kerosene, the vaporizer being kept at the proper temperature by means of a kerosene torch.

Ignition is by the hot tube method, the tube being heated by the vaporizer torch.

A series of tests at various loads was conducted on this engine by Messrs. Black, Manning and Taylor, a party of fourth-year students.

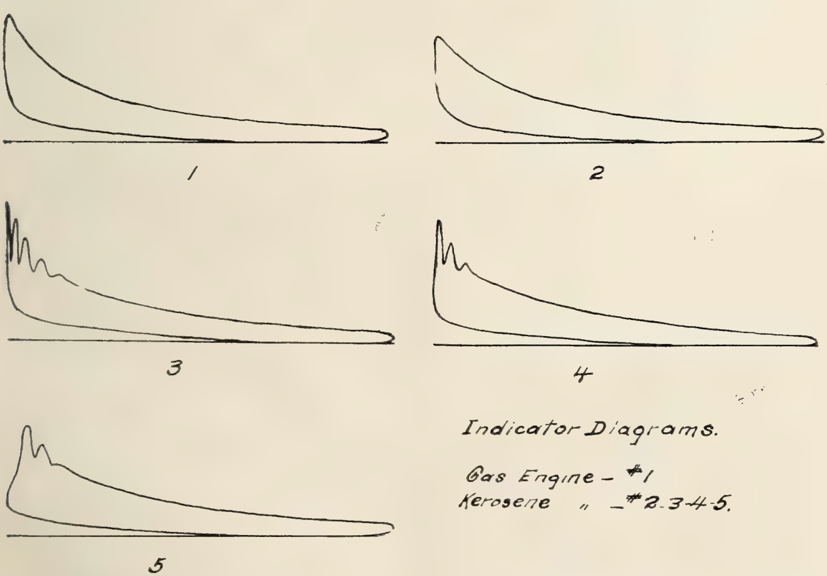
Results of Tests.

Fuel, kerosene.
Compression, 90 pounds per square inch.
Ignition, hot tube.

No. of Test	1	2	3	4
Date	Feb. 17	17	17	17
Duration in minutes	30	30	30	25
R. P. M.	213	220	221	212
B. H. P.	...	1.51	3.03	7.75
Kerosene per hour (lbs.) (Including Torch)	1.937	2.562	3.687	6.187
Kerosene per B.H.P. hr. (lbs.)	...	1.7	1.22	.8

Diagram 1, taken from the engine when it was operating on city gas, is a characteristic card for a gas engine.

Diagram 2, an oil card; is a very good diagram for an oil engine; very few similar cards were obtained during the tests.



To produce this diagram, the treatment of the kerosene must have been under ideal conditions, with respect to temperature of vaporizer, proportion of air and vapor in the mixture, and temperature of ignition tube.

Diagrams 3, 4, and 5 indicate too rich a mixture, a condition difficult to overcome in oil engine work.

NOTE ON THE UTILIZATION OF ATMOSPHERIC NITROGEN.

SAUL DUSHMAN, B.A.

During the last few years a large number of processes have been devised for the utilization of atmospheric nitrogen. The motives for these processes have been two-fold; both in fertilizers and in explosives nitrogen forms a very important constituent. Nitre or Chili saltpeter has been the substance chiefly used for these purposes in the past; but the nitre beds are gradually becoming exhausted, and the world has come to realize that some other source of fertilizers must be sought for if its food supply is to remain assured. At the same time there exists a continually increasing demand from the manufacturers of explosives, for a concentrated nitric acid.

As far back as 1776, Cavendish, the famous English physicist, discovered that an electric spark passed through a moist mixture of oxygen and nitrogen produces nitric acid, and at least three processes are in commercial operation which are based upon this reaction. In the process devised by Birkeland and Eyde in 1904, a 5,000-volt alternating current is passed between water-cooled copper electrodes and by means of a magnetic field at right angles to the latter, the arc is spread out into a disc of over two meters in diameter, thus causing almost the whole volume of air in the furnace to be raised instantaneously to a very high temperature. About one per cent. of the air passing through the arc is thus converted into oxides of nitrogen, which are then washed out by passing the gases from the furnaces through a series of towers. There is obtained in this manner a 50 per cent. nitric acid, which is converted into calcium nitrate by neutralizing with lime. The latter is used as a fertilizer directly. The furnaces used by Birkeland and Eyde were originally of 500 k.w. capacity, but subsequently they were replaced by 800 k.w. units, and at the present time it is the intention to replace these by 1,600 k.w. furnaces. In the first commercial installation at Notodden, Norway, only 1,500 k.w. was used; afterwards this was increased to 40,000 k.w. During 1908, the first year of operation, the total income was $536,000, and the net gain, $134,000. Plants have been established at numerous other places in Norway, where water-power is available, and according to most recent reports the Norwegian industry of manufacturing air nitrates is undergoing rapid extensions involving the expenditure of nearly $15,000,000. Not only calcium nitrate, but also more concentrated nitric acid, nitrate of ammonia, nitrate of potash, as well as sodium nitrate are being manufactured at these plants. One of the principal reasons for the success of the process in Norway is undoubtedly

the small cost of power which is said to be available at about \$5 per horse-power year.

Another process based upon the same fundamental principle is that developed very recently by the Badische Anilin-und Soda-Fabrik. "In this process a continuous arc is produced in a long tube by first bringing electrodes together and then gradually moving them along the tube while the other remains fixed at one end of the tube. The current of air, instead of being passed through this arc, is passed around it through the tube by being forced in at an angle to the main axis of the tube. It is said that the arcs used in this process vary from 35 to 50 feet or more in length, and are maintained continuously for days or even months at a time."

Besides these two processes which are both in successful commercial operation, there is a third process for the oxidation of atmospheric nitrogen which has been devised by H. and G. Pauling, and is working on a large scale near Innsbruck in Tyrol. The electrodes are curved like the electrodes of the so-called horn lightning arresters. The arc is started at the narrowest part between the electrodes by means of a special lighting device. The air current passed through the arc blows it out to a considerable distance and thus increases the volume of air heated to the extremely high temperature at which combination occurs. "The twenty-four furnaces at present installed in this plant have a total capacity of 15,000 h.p. Two other plants, each of 10,000 h.p., for carrying out the same process, are in course of erection, one in Southern France, and the other in Northern Italy."

The process of Frank and Caro for the utilization of atmospheric nitrogen is totally different from any of the above methods. Nitrogen is passed over heated calcium carbide and the result is the formation of a substance having the formula $CaCN_2$ and known as cyanamide. Investigations at numerous agricultural stations have shown that it can be successfully used as a fertilizer, and accordingly a large number of plants are being erected both in Europe and America for its production. The United States Cyanamide Company has a 5,000-tons works at Niagara Falls, Ontario, and is also building another plant in Tennesee. Cyanamide is also of interest on account of the number of interesting derivatives which it is capable of yielding when treated with different reagents. An important reaction is that with steam, leading to the formation of ammonia, which may be subsequently converted into ammonium sulphate.

Still another method for the utilization of atmospheric nitrogen has been devised recently by F. Haber and patented by the Badische Anilin-und Soda-Fabrik. A mixture of nitrogen and hydrogen in the required proportions is maintained at a constant high pressure and heated in presence of a catalytic reagent (such as finely divided iron or osmium) to a temperature which

varies between 400° and 800° C. Only about 8 per cent. of the mixture is converted into ammonia, but the power necessary for the compression and circulation of the resulting gases is very small, and it appears very likely that in the near future this process will be exploited industrially.

TECHNICAL EDUCATION

A Synopsis of the Discussion at a Meeting of the Engineers' Club, October 13th, 1910.

Dr. Galbraith, *Dean of the Faculty of Applied Science and Engineering.*

Mr. Chairman and Gentlemen:—The object of having a discussion on this subject by the Engineers' Club is for the purpose of presenting some of our views to the Royal Commission on Technical and Industrial Education. Thinking that the members of the club might have some ideas on this subject which they would like to present, I asked the Commission if they would care to receive our views. They assured me that they would welcome such opinions, and would be glad to receive them upon their return to Toronto for the examination of witnesses.

To-night I am asked to open the discussion, and do not propose speaking longer than is necessary to present the question and to elicit the opinions of the members of the club who are present.

The term "Technical Education" is very broad, so broad indeed, as to be almost vague. The Faculty of Applied Science in the University of Toronto, covers only one branch of the subject, and it may be the duty of the Commission to study the question in its most general sense.

The name is almost a misnomer, as usually applied. The word " technical " really means, "relating to the art of making things or doing things"; for example, a trade education in the methods of making things or the doing of work by manual labor is technical in the original sense of the word. The expression is now applied generally, to training in practical science.

As an illustration of some of the difficulties in technical education, if you turn to the curriculum of the Toronto Technical School, you will see that very nearly the same subjects are taught in the evening classes as at the University in the Faculty of Applied Science. A stranger, not knowing the circumstances could not make any distinction. Now, the difference is this: the objects of the Faculty of Applied Science are well defined; they are limited by the nature of the professions to which the training is directed, and consequently, it is comparatively easy to construct the curriculum. But in the case of the municipal technical school, the students come from all sorts of positions

and trades. They often have no definite object in view. One desires one thing, another wants something else. It is hard to determine what to include and what to leave out, and this is due to the fact that the requirements of the students vary. They cannot be divided into graded classes as are the students in the Faculty of Applied Science. They require to be treated as individuals rather than in classes.

Another difficulty is this: in the university (I am not speaking of Toronto only, because the principles apply generally), the matriculation, or entrance examination, whatever its weaknesses may be, accomplishes one object. The students know at the beginning, and the teachers know, just what the qualifications of the students are. The instructor knows where to begin, and this in itself is a great advantage. In the evening classes of the Technical School the situation is quite otherwise. Satisfactory grading by means of an entrance examination is difficult or impossible. These difficulties in the case of the evening classes came under my observation when a member of the board of directors some years ago.

The teaching of trades in the municipal school in a place like Toronto is rendered difficult by the great number of trades to be considered; the cost would be enormous. Again the problem is made more complicated by the attitude of the labor unions. The representatives of the unions at the time I speak of were in favor of teaching practical science, but opposed to teaching trades. The problems to be solved in the case of the Toronto Technical School will be the problems of the municipal technical schools in the majority of Canadian communities.

There is a noteworthy movement that is taking place in America, viz., the teaching of the trades by the people who are most interested in them. This seems only common sense. It is being done by the larger corporations; the Grand Trunk Railway, and the Canadian Pacific Railway have begun this work in Canada. They have their own schools for their apprentices, who receive instruction in both the theoretical and the practical sides of the trade, and the results are very encouraging. The instruction books used by these corporations are very well adapted to their purpose. While a man is working on one machine, he is given a blue print describing the machine to be taken next. He studies this, and is able to answer theoretical questions relating to the machine by the time he is moved on to it. This plan is being used also, by the Baldwin Locomotive Works, in Philadelphia, and in many other large plants. It is adopted by a number of the largest corporations, and is done for purely business reasons. There is no philanthropy entering into the question, for corporations have no souls, and only work for the dividends. In these corporation schools there are two classes of students as a rule, viz., the men from the universities and the men with only a common school education. The trade educa-

tion of these men, while extremely practical in both cases, is different, for the reason that they are needed for different purposes.

Much the same system obtains in Germany. The cases of which I have heard are in the manufacturing works in which applied chemistry is the fundamental science. The laboratory is located in the works. The best trained men are taken from the technical high schools and placed in these works, where they are trained in the methods of the company. It seems that where the employee is trained by the employer the result is mutually beneficial. It is not like the training of a group of men for something they may never follow afterwards.

There is not much respect shown by students for a teacher, whether in theory or practice, unless he is an expert in what he teaches. If we are to make any progress in the teaching of trades, we must have men who are skilled in the trades they propose to teach, and these men are what the Grand Trunk and Canadian Pacific Railways have. They have also practical men who can teach the necessary theory.

To obtain teachers with suitable qualifications will prove one of the greatest difficulties in teaching trades. I believe some teachers can be obtained in Canada. I know that among the young men who enter the Faculty of Applied Science there are some expert mechanics, and these men when they graduate may be used as teachers, since they would be equipped to teach both theory and practice, and could hold the respect and interest of the pupils. But not every graduate in mechanical engineering could do so, because as a rule, when he graduates, he is neither an engineer nor a mechanic. The difficulties of obtaining teachers for trade schools will naturally be greater at the initiation of the work than afterwards; demand will doubtless encourage a supply.

I have now touched upon a few of the leading points as they occurred to me. I have not gone into details, but have attempted rather to present the subject to the Engineers' Club in such a manner as to suggest questions for discussion.

Mr. R. W. King, *of Robert W. King and Co., Architects and Engineers, Toronto.*

I would like to emphasize one point made by Dr. Galbraith, which is, the absence of localization in the different industries. This has been one great difficulty confronting technical education.

I had an opportunity of seeing this in connection with the trade of knitting. There are certain centres given to this trade. In England it is Leicester. Weaving had a centre at Nottingham, while in Germany there were other centres for these trades. In Leicester and Nottingham and in some of the other centres, trade schools and technical schools are to be found, because there is where the industry flourishes. The government

makes grants to these schools with a view to an increase of the staff. Germany set the example by instituting an immense school where trades desired by the community were taught. Its students were taught how to do their work intelligenly. This was the sort of education that England found it necessary to adopt, and they sent their teachers over annually to get pointers. I have no experience outside the fabric industry, but I would be especially interested in seeing the experiment tried in that line.

I suppose the same would apply in other parts of the country where these centres exist. In Ste. Hyacinthe, Quebec, there is a centre for woollens and knitted goods. In Ontario we have Paris. Now, if we are going to follow the example of the Old Country, it is in such places that the technical or trade schools, should be placed, and maintained by the government, I believe it would be to the advantage of the country to centralize the trade. You could not hope for much success in Toronto, I fear, because of the great variety of trades being followed.

C. H. C. Wright, *Professor of Architecture, Faculty of Applied Science.*

Dr. Galbraith has given you the academic side of this question, and I do not think that I can add anything to what he has so ably said. I believe that if the Manufacturers' Association deem it necessary to place their notes before the Commission on this subject, then the members of this club should also present their views; and I would like to hear what difficulties exist to you. What are your difficulties as practising men? Do your mechanics, machinists and artisans understand your instructions? Do they read the drawings, or do they blunder through them, making mistakes that cause endless trouble for you and for themselves? I would like to hear what these troubles in handling men arise from. I am not prepared to say that we have missed the cue, educationally, although there may be improvements necessary. We should know what the real difficulties are, the existing conditions, so that we can work together to clear them out of the way. I believe you men who are out in the practising world are the ones who have met the difficulties, and these are the things that I believe should be brought before the attention of the Commission.

T. Aird Murray, *Consulting Municipal and Sanitary Engineer, Toronto.*

I have been asked to give in a few words my ideas as to how far and in what way methods of education can be outlined to produce what is technically called a " Sanitary Engineer."

I understand that views expressed to-night are to be laid before a commission whose business is to report upon technical education.

My difficulty is at once apparent. I am not sure as to the exact classification of a " sanitary engineer," whether it should

be "technical," "practical" or "scientific." But surely when we consider the point, does not this difficulty of definition apply all around? I cannot see that there can exist any such separate thing as technical education, no matter how much we may have got used to the term, as applied to those forms of education which are calculated to produce the man who actually performs. The theory, or principle, of equilibrium has always appealed to me as something of a natural force, producing the maximum efficiency. Therefore I do not ask, "Is a man technical?" "Is a man scientific?" or "Is a man particularly this or particularly that?" But I do want to know, are his actions based upon deduction or are they merely instinctive? The principle of deductive thought as separate from instinctive thought, appears to be the main quality distinguishing the so-called " human " from the general " animal " class of creation. Now, how can a man be " technical," as apart from " instinctive," unless his technical effectiveness is based upon deductive formulae.

It is useful that a man should knock a nail skilfully, truly and with precision, but if the action is controlled only by the instinct which causes a bird to build its nest with precision, he is no more than an instinctive animal. The man should, at the back of each knock, feel and know all the reasons and accumulative evidence which make for what is termed efficiency in work. Absolute efficiency in production is found in machine results; machine termination is the result of scientific application. The man must be superior to the machine; and must, therefore, be something more than a tool capable only of producing technical results.

But what has this to do with sanitary engineering? Simply this, you can no more make a purely efficient technical sanitary engineer than you can make a purely efficient scientific sanitary engineer. The efficient product must represnt a combination, and must result in equilibrium. This fact is being recognized in older countries. The United States of America in their universities, and European centres of research work as exemplified in the Hamburg State Institute of Hygiene recognize sanitary curriculums. Generally speaking, apart from the special sanitary engineering course at McGill University, nothing is doing in Canada. What is the result in Canada? We see, whenever an expert is required to advise on sanitary matters, an outsider called in. We train men in the problems of surveying and laying out a new country, in railway work, bridge building, and all the requirements of transportation, in fact, in everything of a utilitarian nature, even to the harnessing of our rivers for power; but in the maintenance of ourselves in a normal state of health, not only in health, but in a mere state of existence, we have no curriculum of training.

I have used the term " a mere state of existence," because one fact stands out plainly (all who run may read), a popula-

tion cannot grow beyond the available water supply at the rate of at least thirty gallons of potable water per head per day. Apart from our ideal and practical thought of dominion, our calculations of serial production, our schemes of railway development, grain elevators, and multitudinous efforts and methods of transportation and inhabitation, no two people can exist, and no community can grow beyond " available water supply."

Here comes in the " sanitary engineer," the man who can weigh up both physical and chemical data and draw deductions, and tell a community just how far it can grow, and where it must automatically stop. Now what does this mean from the sanitary engineering educational point of view? It means a man trained not only in taking levels, making surveys, measuring quantity and estimating the cost of work, but in estimating the amount of character of available water within a given area.

This takes in a great deal more than what is generally called "technical engineering." The character of any water, apart from its quantity, is surely most important. Underground water is not only water, but is also a mixture and chemical compound or compounds; its constitution depending upon the absorbed and soluble quantities of foreign matters taken up from strata. Surface water, in its constitution as far as admixture appertains, is dependent upon the absorption and mixtures of forms of vegetable growth and decay.

Water, as generally found, is, in fact, not water as represented by H_2 O. in our text books, but presents other and more intricate chemical formulae, sometimes inorganic, sometimes organic, generally a combination of both, but seldom water.

Now the conclusion of the above is simply this. Certain defined lines of education are required to include a curriculum of training which will produce not only a so-called " technical man," or man who can measure a quantity and show how the quantity can be delivered, but one who can also determine the exact quality of the quantity in its relation to public health. Such constitutes the true definition and training of a sanitary engineer in at least one of the aspects; I maintain that this definition holds good throughout. To put the matter in a nutshell, in a light plain to everyone, I would ask the question, " Where can I get the man trained in Canada as an engineer, who, if I put before him an analysis of a peculiar liquid or sewage, could produce on paper another analysis and show the cost and method of obtaining a defined change? I can get plenty of men from the schools who can do mechanical drafting or instrument work, but the man who can think and deduct from natural phenomena are few and far between.

Now, natural phenomena is not a hidden basis of action, but is the hypothesis of all formulae. Therefore, I consider that technical education should be based upon this ultimate basis of things. If I were asked to generally define the lines of educa-

tion for a sanitary engineer, I would, by simply stating that there should be added to the general engineering course, a course in organic and inorganic chemistry, together with a knowledge of bacteriology as affecting the transmission of what are generally termed water borne diseases, as well as affecting the various fermentation processes for breaking up organic compounds.

There are times when one has to listen to sentiments of depreciation applied to scientific men particularly, and to such phrases as "an ounce of practice is worth a ton of theory." All attempts to separate theory and practice are vain and foolish, and are the products of primitive ignorance. It is well to remember that the scientific man may be apt to know, while the other is apt to guess.

All that I have said up to the present may apply to the sanitary engineer, but I am inclined to think that the work of the Commission appertains to an enquiry more into the fitness or possible fitness of the man who may be employed by the engineer to execute or carry out his plans. The man who receives instructions and has to technically carry them out forms the material with which the Commission may have particularly to deal. This man cannot efficiently be produced by any method of any education apart from apprenticeship and practice in the particular line of work.

Sanitary engineering demands a host of so-called "technical men." The man who can actually go into a sewer trench and make a really watertight joint, or a lead joint in a water main, the efficiency of both sewerage and water supply depend almost entirely upon this man. In Great Britain we have associations of managers of waterworks and engineering installations which include so-called technical men, and who are simply the product of a demand. It strikes me that, after all, the law of demand and supply is the first cause instrument which produces the technical man, and his efficiency depends greatly upon the extent, character and amount of work which falls to his lot. The efficiency of the tool is in proportion to the efficiency demanded of the tool, and this simply brings me back in a circle to the point at which I started. The efficiency of technical work, if the product of deductive reasoning as apart from instinctive, depends upon the general and all-round training of the man who originates and who has the power to direct completion.

A. H. Gregg, *of Wickson and Gregg, Architects, Toronto.*

I hope to see something done, not only for architectural students, but for the trades that come closely in contact with the people. To my mind the great difficulty is that the people lack interest in the trades they are following.

An example of this was brought to my attention recently. A printer in this city received a large order for books and found it necessary to engage nine additional printers. He had to discharge the nine men almost at once because he found that they

lacked sufficient knowledge of type-setting. Now, it would seem a strange condition of affairs that these men actually lacked such an essential qualification of a printer.

A short time ago we were building a manufacturing plant in which we had to have a small power plant. One morning I went there and found that one of the plumbers had prepared a complete drawing of the principal apparatus, showing the location of every valve in it. This man had done so merely because he loved his work and had been taught to think.

Now it seems to me hopeless to try to teach men their trades unless they can be first taught to think. Their education should be brought to the point where they can reason out their work.

The printer I have mentioned told me that they could not get apprentices to stay, because their life was made miserable by the journeymen. In the profession of architecture we are in a peculiar position. For ages the architect had been trained very much as we read in "Martin Chuzzlewit," where Mr. Pecksniff, having received the pay for his instruction, turned the student loose to draw the cathedral, or what he pleased, allowing him to be his own master. Things have changed to-day. The larger offices are run on business-like methods. Few of the large offices, however, care to take on a man to teach him. They do not wish to be bothered with him. They do not think this the proper place for a student. It seems to me to be the business of the people to train architects, because there is nothing that comes more directly in touch with the citizen than the work of the architect. Evidently the government should take an interest in this question. It certainly is a point that should be brought to the attention of the Commission.

L. V. Redman, *Department of Electro-Chemistry, Faculty of Applied Science.*

Dr. Galbraith has pointed out that education could be theoretical sometimes, and sometimes practical; while under certain conditions it could be both theoretical and practical, but unless the practical could be well taught, it had better be left out. In this connection I might mention Professor Duncan, of the Kansas State University, who started a department in connection with that institution, the results of which have exceeded even the greatest ambitions of the founder, although the department is but four years old.

The idea is this: A graduate of the university enters the employ of some large manufacturing concern, in the field of research work. He continues using the laboratories of the university, and devotes a certain portion of his time to the problem they have set him. His other time is devoted to the teaching of undergraduates of the institution. A certain fixed sum is given him as a salary by the concern, and a bonus is also given

him if he solves the problem upon which he has been working. One such man found the process of making what is known as salt-rising bread. He isolated the particular culture that was necessary to make the yeast. As the consumption of this class of bread reaches a value of approximately four hundred thousand dollars per year, and as the discovery was made at the expense of about fifteen hundred dollars, the results are indeed worthy of special note.

Another man worked on the caseins present in butter for the interests of those engaged in the shipping of large quantities of butter. He discovered a process which will net for his company the sum of one thousand dollars a day.

Hence it might be well to consider such a scheme in connection with our university. The man would be no expense to the university, except for the room he would require to work in, and the possible discoveries made by him would offset this. It seems to me that it would be a good investment, both for the university and any large company that employed such a man.

C. R. Young, *Department of Applied Mechanics, Faculty of Applied Science,.*

Those in need of technical training may be divided into two classes: first, the professional class, composed of men destined by natural gifts or other advantages to occupy positions of large responsibility, and, second, the skilled laboring class.

From the fact that the representatives of the first class, viz., the practising engineers, or the engineer-managers, as they may be called, are occupied to a large extent in dealing with men, and as their power extends, to a less and less extent with things, the preparatory training for such should be essentially broad in its character. For this reason it is possible to train men to enter all branches of engineering at a single technical college.

The skilled workman is essentially a specialist, since proficiency in the handling of tools or in the carrying on of complex industrial processes is attained only after years of practice along a single line. It is even said in this connection that the difference can be noticed between a workman who has only his own experience behind him, and one whose ancestors for generations back were engaged at the same occupation. The skilled operator or workman, therefore, requires special instruction in the particular craft which he is to follow, and a technical school, to be of most value to him, must be most capable of affording assistance in his own branch of work. In this respect the training for skilled workmen differs essentially from that found most satisfactory for engineers.

A very important service which technical education may perform to assist the engineer in the conducting of his operations is to provide special instruction to those whose duty it is to carry

his orders into effect. No one knows better than the engineer the difficulties encountered in avoiding errors of all orders of magnitude in the progress of engineering works. Sometimes this is due to carelessness, but most frequently to the inability of those engaged upon the work in the field to grasp the purpose and intention of the engineer. It may be due to lack of familiarity with plans and specifications, or inexperience in field operations, but the most serious errors arise from ignorance of the simple natural laws upon which the work is based. Thus, to cite actual instances, a contractor's foreman may place the vertical reinforcement of a retaining wall in the centre of the wall rather than at the back, or main reinforcement for a concrete beam at the top instead of at the bottom, and an inspector may quite as innocently decide that anchorages for the posts of a windmill tower are uncalled for, since the legs are battered, or that a form is capable of sustaining as much green concrete as can be dumped into it. As a means of lessening the likelihood of such errors as these, any arrangement by which contractors' foremen and inspectors on engineering or building work might receive elementary instruction in mechanics would be welcomed. At present the only means of this character generally available are afforded in the courses of the correspondence schools, but these can never equal personal instruction in efficiency.

T. R. Rosebrugh, *Professor of Electrical Engineering, Faculty of Applied Science.*

About twenty years ago I had brought to my attention a case which would be quite different in Toronto as regards the trade school, I refer to an institution in New Jersey, where there were but two industries engaged in—making of locomotives for the boys, and the silk industry for the girls.

It seems to me that the weakness of the present system is due to the separation of the two classes; the men brought up in the trades, and the men educated for professions at the universities.

I had some conversations some time ago with an engineer in charge of a large mechanical industry in this city, and he told me that it was next to impossible to get intelligent young men who would take an interest in some of the trades, for example, in foundry work. He thought it would be a great opening for any young man to devote himself to such work, and become a leader in that line.

Regarding the school system, it would appear that the child's time is considered as a by-product, something to be treated as having little value. If it were possible to include in the studies a few things that would be of vital importance to the young apprentice, at the same time allowing a good sound knowledge of the English language, no doubt much of the time spent in lengthy parsing of verbs could be devoted to instruction that would help the boy in the trade work of after years.

BOOK REVIEWS.

Heat Engines (being a new edition of "*Steam*") by William Ripper; Longmans, Green & Co., 1909; cloth.

The character of this little work of some 312 pages is fairly well set forth in the preface where the author states that it "has been written as an introductory text book for the use of engineering students, and more especially for those who already have some practical acquaintance with the manufacture and use of machinery." It originally dealt only with steam machinery, but the present edition includes internal combustion engines as well.

The whole problem of the production and use of steam is dealt with in a very elementary way, beginning with the general effects and transfer of heat, the properties of steam, and passing on to the steam engine. The various parts and accessories of a steam engine, including the details of the machine itself such as the valve gear, the crank, cylinder, governor, etc., are then discussed along with the various types of condensers in use.

The compound engine is treated with a fair degree of completeness. One might have expected a somewhat more complete treatment of the indicator than has been accorded it, but as the book is intended to be introductory, probably no more space could be allotted for this purpose.

The chapters on the boiler and combustion are well arranged to give a knowledge of the conditions of combustion and economy.

The last two chapters deal with the steam turbine and the internal combustion engines, and the book concludes with a series of helpful questions bringing out the essential features of the various chapters. On the whole, the book is well illustrated, and should serve as a very good treatise for the beginner, and should also be helpful to the practical man. A number of problems are worked out through the book, and they are all put in such form that a knowledge of arithmetic is sufficient to understand them completely.

Reviewed by R. W. Angus, B.A., Sc., Professor of Mechanical Engineering.

C. M. Canniff, '88, has entered into partnership with Mr. John S. Fielding, as Fielding & Canniff, civil engineers, 15 Toronto Street, Toronto.

J. W. R. Taylor, '08, is in the employ of the William Hamilton Co., Peterboro'.

W. G. Swan, '05, is divisional engineer for the C.N.R., near Vancouver, B.C.

APPLIED SCIENCE

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EDITORIAL

Introduction '10-'11

Applied Science begins it fourth year with the publication of this number. The new horse between the editorial shafts does not purpose making any material change in the direction of the journal's progressive course. Comparing it with his concept of the labor necessary to begin, three years ago, he finds it now an easy-turning vehicle. Rocks and ruts that rose prodigiously large then, are hidden now in dust.

For all this the graduates of the Faculty of Applied Science owe much to the former editor-in-chief, for the arduous effort and enthusiasm which the success of Applied Science during the past three years bespeaks. On behalf of them we wish Mr. Mackenzie at least the same measure of well-merited success in his new undertakings that they have seen the journal experience while under his supervision.

Co-operation

Since its debut, Applied Science has not failed as a link of communication and a binding tie between the undergraduates and the alumni. From its pages the latter have read the papers delivered to the former as members of the Engineering Society. The benefit derived thus has been mutual.

The journal has, in turn, profited by the loyal co-operation the alumni has given it. The result is a recognized leader in the broadcasting of technical and engineering literature.

Opportunities for advancement are many, and a voice from its readers throughout its expansive field in Canada and the United States, in the form of papers, discussions, or plain, unvarnished criticisms will aid very materially in this advancement.

Every issue contains an article of more or less especial interest to every graduate; a problem, perhaps, concerning which his own candid opinion has, for some time, sought an airing; a subject upon which a paper may have been commenced, but never finished, or finished but never submitted. Let us hear from you.

Vacation Work

One of the articles in the make-up of this issue is a synopsis of the discussion on the problem of technical education, which took place at a meeting of the Engineers' Club Club on the evening of Oct. 13th. It is evident, from a perusal of the article, as well as from the study of general industrial conditions, that the Commission on Technical Education has before it in its endeavor to produce an improvement along educational and industrial lines, a task as gigantic as the freedom of scope and powers of investigation it possesses. Although the engineering profession is but one of the numerous branches subject to its examination, it is, at all events one of the most important, and as some will say, one of the most needful of improvement. It may be expected, therefore, that the Commission on Technical Education will enact some very helpful suggestions as a result of its thorough investigation.

One problem there is, however, for which we need scarcely expect from them a speedy solution, and which, consequently, might well be considered by ourselves, namely, that relating to vacation work for under-graduates. Every October returns to us men who have spent the summer in search for experience they know to be necessary for the rounding out of their college training. Every October hears various opinions as to the efficiency of this vacation work in connection with the theoretical training received during the college year. The reasonableness of the variety of opinions is well worth considering. Would an increase of thought and consideration as to a more satisfactory combination of the electrical course or the mechanical course, and the vacation work the student obtains be worth the trouble? Obviously so, as this

is the only present outlet into the broader channels of co-operation between the course in, say, mechanical engineering, and the mechanical industry itself. The engineer-to-be must combine theory with practice somewhere. The complete undertaking is impracticable in the college alone, because mechanical equipment and methods of mechanical operation are too changeable to be kept up-to-date, since their speed curves do not coincide with that of the financial resources of the college.

If we step thirty years backward we note the establishment of electrical engineering courses as a response to the call of the industry itself. The same applies to the mechanical and other engineering courses—each the result of demand. The technical course is, in every case, the servant to the practical industry.

Methods are being employed in Great Britain, in Germany, and in the United States, by engineering institutions, to develop as high a degree of efficiency as possible in the service they render to industrial development. They do well to utilize the voluntary assistance of the manufacturers themselves, since neither body can alone substantially lessen the gap between, let us say, the ideas occupying a student's professional mind upon leaving the factory in September, and those which slowly trickle in after a few weeks in the lecture room. (The fact that it requires several weeks at both ends of the college year to adapt one's self to one line of mental activity after having pursued another for some months, is in itself an indication of a greater diversion between them than should exist). Both the employer and the university are trying to bring into alignment these separate occupants of the student brain. What they might do working in conjunction ought to be a topic interesting to both, and would undoubtedly prove interesting to the under-graduate, as it would be the means of moulding college course and apprenticeship course into a more compact form, perhaps lessening by a year or more the time required at present to complete both.

The shortest distance between the two points of inexperience and industrial efficiency is along the line of co-operative education. In view of this, a commission consisting of representatives of, let us suggest, various firms in the electrical industry, and of men from the departmental staff of the engineering school could, without making gigantic concessions on either side, map out a course of training that would render the students' vacation work of more assistance to his electrical engineering course, and thus of more assistance to his industrial life.

The other departmental courses could be materially improved by much the same procedure.

OUR REPRESENTATION IN THE SENATE.

The Result of October Elections.

The elections of a month ago resulted in the re-election of C. H. Mitchell, C.E., and E. A. James, B.A. Sc. to represent the graduates of the Faculty of Applied Science and Engineering in the senate chamber of the University. Both these men have taken at all times a very deep interest in the affairs of the Faculty of Applied Science, and in the progress in engineering that its graduates are affecting in the Dominion and elsewhere. Both are well qualified, from an engineering point of view, for the work that has been entrusted to them by these graduates.

E. A. James, B.A. Sc.

Mr. Mitchell, and his experience as a practising engineer, are well known throughout Ontario, especially in the Niagara Falls district, where he spent his first eight years after graduating, in designing and managing the construction of various municipal projects, chiefly Hydro-Electric. Later he became chief of the Mechanical Department of the Ontario Power Company, of Niagara Falls, which position he retained until 1905. Since that date Mr. Mitchell has been a resident of Toronto, a member of the consulting firm of C. H. and P. H. Mitchell.

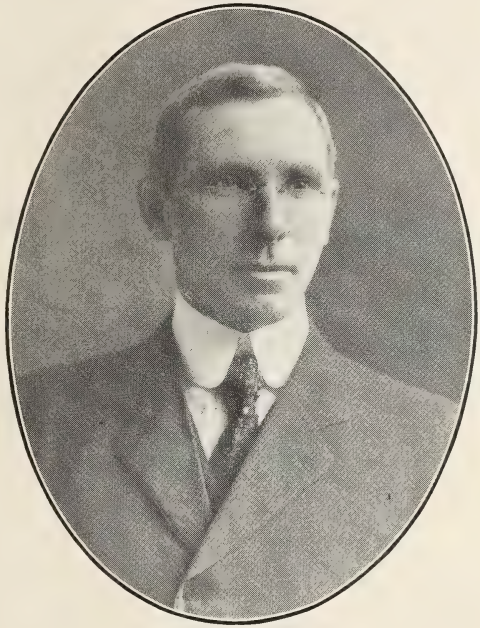
Some years ago Mr. Mitchell made a tour of inspection through Europe, investigating the results there of modern engineering practice.

He has been for some time a member of the executive of the Canadian Society of Civil Engineers, and two years ago was chairman of its Toronto branch.

Mr. E. A. James is a more recent graduate of the Faculty of Applied Science, and consequently, is more in touch perhaps, with the majority of younger graduates. He was a member of

the class of '04, and in the following year was elected by the Engineering Society as its president. Later he became associated with several civil engineering enterprises in western Canada and in northern Ontario, where he was superintendent of
ciated with several civil engineering enterprises in western Can-
Canadian Pacific Railway.

Some 3 years ago Mr. James entered the field of journalism, and as managing editor of the *Canadian Engineer*, has evidenced his ability by the journal's rapid development into the service it now renders to the profession in Canada.


C. H. Mitchell, C.E.

Mr. James is still actively engaged in engineering himself, being town engineer for North Toronto. He is an Associate Member of the Canadian Society of Civil Engineers.

In all there were five candidates for the two senatorial chairs. These were C. H. Mitchell, '92, of the firm of C. H. & P. H. Mitchell; A. F. Macallum, '93, engineer for the city of Hamilton; W. E. H. Carter, '98, of E. T. Carter & Co.; E. A. James, '04, of the *Canadian Engineer*, and T. H. Hogg, of the Ontario Power Company, Niagara Falls. To the successful candidates Applied Science extends sincere and hearty congratulations.

BIOGRAPHY.

R. W. Leonard, C.E.

Reuben Wells Leonard, the contributor of the first article in this number of Applied Science, is a native of Brantford, Ont., and a graduate of the Royal Military College, Kingston, winning a silver medal in the class of '83.

Since graduating he has followed his profession for the most part in Canada, but for some little time in the United States and in Central America, taking up railway construction, mining, and water power engineering.

For two years following graduation, Mr. Leonard was instrument man and engineer in charge of construction on the Canadian Pacific Railway north of Lake Superior. In 1885 he served in the North-West Rebellion on various staff appointments. Later he acted as engineer on Canadian Pacific Railway surveys and construction work in Manitoba and Ontario.

From 1886 to 1890 he was chief engineer for the Cumberland Railway and Coal Company, of Nova Scotia. For the following sixteen years Mr. Leonard has served as engineer and manager of construction on various portions of the Canadian Pacific Railway from Quebec to British Columbia, on the St. Lawrence and Adirondack Railway, on the Rutland Canadian Railway, on the Cape Breton Railway, and as contractor on the Parry Sound Railway.

In water-power engineering he has constructed hydro-electric plants at Niagara Falls, Ont., near St. Catharines, Ont., and for the Kaministiqua Power Company at Kakabeka Falls, Ontario.

In 1906 the Coniagas Mines, in which Mr. Leonard has a controlling interest, created no small stir in the mining world, and carried away much of his attention from his civil engineering projects. About this time he built a smelter at Thorold for the refining of silver ores. In 1909 he became actively interested in the copper claims at Bruce Mines, Ont., in which work is being carried on briskly at present.

Mr. Leonard is president and general manager of the Coniagas Mines, Limited, with its subsidiary enterprises, the Coniagas Reduction Company, at Thorold, and the Redington Rock Drill Company. He is likewise president of the Bruce Mines, Limited. He is vice-president of the Canadian Society of Civil Engineers, and vice-president of the Canadian Mining Institute.

Last spring Mr. Leonard received an appointment to the Board of Governors of the University of Toronto.

Herbert Johnston, '03, is town engineer for Berlin, Ont.

A. A. Ridler, '07, is with the Constructing and Paving Co., Toronto.

ENGINEERING SOCIETY.

As in previous years, the Society executive is alternating its general meetings with others for the different departments. This plan has met with much success, since it was inaugurated, in providing papers and discussions that sustain the interest of all the members.

The first general meeting for the year was held on Wednesday, Oct. 5th. It was addressed by President Falconer, Dean Galbraith, and R. W. Leonard, C.E., and was attended by quite a number of the graduates, in addition to a full attendance of student members.

The resignation of W. A. Gordon, '10, newly-appointed treasurer for the Society, was accepted, and the ensuing nomination resulted in the election by acclamation, of M. B. Gordon, '10.

On Oct. 19th, the various sectional meetings of the Society were held. The electrical and mechanical sections heard Mr. H. W. Price, the civil and architectural sections, Mr. T. R. Loudon, while the chemists and miners were addressed by H. L. Batten, '11.

On Wednesday, Nov. 2nd, Mr. T. Aird Murray, C.E., spoke to those present at the general meeting on "Water Purification." His interesting and instructive paper was well illustrated by slides.

On Monday, Oct. 24th the men of the fourth year went to Niagara Falls, and investigated the various hydro-electric installations there. The excursion was in charge of Professor Angus and Mr. Price, and was taken advantage of by over one hundred men.

WHAT OUR GRADUATES ARE DOING.

This section is conducted with a double object in view: first, to give the graduate professional news of each other; second, to give the undergraduates an idea of the possible fields of employment open to them in the future.

W. A. Gordon, '10, is in business at Sundridge, Ontario, as a member of the firm of Gordon & Thornton, lumber merchants.

Guy Morton, '09, and R. S. Davis, '07, are managing the Calgary branch of the Canadian Westinghouse Co.

C. J. Porter, '09, is with the B. C. Electric Railway Co., Vancouver.

Gordon Kribs, '05, is with Smith, Kerry & Chace, as manager of their newly-opened branch in Portland, Oregon.

A. A. Kinghorn, '07, is in the Roadways Department, City Hall, Toronto.

W. D. Black, '09, is with the Otis-Fensom Elevator Co., as superintendent of their eastern branch, with headquarters in Montreal.

E. A. Jamieson, '10, is C.P.R. inspecting engineer for the Okanagan district, Kamloops, B.C.

T. A. McElhanney, '10, is on geological government work in Vancouver.

A Gillies, '07, is resident engineer on the construction of a power plant at Minnedosa, Man.

A. J. McPherson, '93, has been appointed municipal commissioner for Regina, Sask.

E. L. Cousins, '06, is assistant engineer for the city of Toronto.

W. G. Turnbull, '09, and P. J. McQuaig, '09, are in Milwaukee, Wis., with the Allis, Chalmers Co.

Leslie R. Thomson, '05, has been appointed lecturer in drawing, University of Manitoba.

F. F. Wilson, '09, is with a Mitchell survey party at Smoky Lake, Alberta.

George A. Tipper, '09, is also on survey work, with A. L. McNaughton, D.L.S., at Heatherwood, Alberta.

H. W. Fairlie, '10, has accepted an appointment with the Tungstolier Company, of Canada, Limited.

Wilfred C. Cole, '10, is with the Central Colorado Power Company, in their Shoshone hydro-electric plant, on the Grand River, Colorado. This company is supplying the city of Denver with the major part of its lighting and power requirements by a transmission line 150 miles in length, over the Rockies. The power is supplied at 100,000 volts.

G. E. Woodley, '10, has since graduating, been with the Westinghouse Electric and Mfg. Co., East Pittsburg.

C. R. McCollum, '09, and W. J. McIntosh, '09, are in the employ of the Otis-Fensom Elevator Co.

C. E. Toms, '09, is with a survey party in British Columbia.

G. E. McLennan, '10, and A. S. McArthur, '09, are on D. L.S. work near Prince Albert.

G. E. D. Greene, '09, is on railway survey work in eastern Ontario.

Othmer Ross, '10, is in the draughting office of the Dominion Bridge Co., Lachine.

Among the recent staff appointments in the Faculty of Applied Science and Engineering are the following:

H. E. T. Haultain, C.E., has been appointed Professor of Mining.

J. J. Traill, '05, and W. W. Gray, '04, have been appointed lecturers in mechanical engineering.

J. A. Stiles, '07, and R. E. W. Hagarty, '07, are demonstrators in drawing.

W. C. Blackwood, '06, is demonstrator in the department of physics.

N. H. Manning, '09, has been appointed demonstrator in thermo dynamics.

H. A. Cooch, '09, is demonstrator in the department of electrical engineering.

J. T. Lagergren, formerly of Sweden, has been appointed lecturer in machine design, and is in charge of the draughting room work of that department.

J. E. Keppy, '06, has accepted a position on the staff of the Canadian Inspection Bureau.

A. U. Sanderson, '09, is at present at work on the new filtration plant.

OBITUARY.

It is with sorrow that we report to our readers the death of H. S. Fierheller, B.A. Sc., a member of the class of '06, which took place at his home in Toronto in May, 1910.

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